Claims

We claim:

1. A method for increasing an electrical resistance of a resistor, comprising the steps of:

providing a semiconductor structure that includes the resistor; and

oxidizing a fraction F of a surface layer of the resistor with oxygen particles, resulting in the increasing of the electrical resistance of the resistor.

2. The method of claim 1, wherein $F = 1$.

3. The method of claim 1, wherein $F < 1$.

4. The method of claim 1, wherein a dimension of the portion of the resistor does not exceed about 1 micron.

5. The method of claim 1, wherein the oxidizing step includes:

placing the semiconductor structure in a chamber;

including a gas within chamber, wherein the gas includes the oxygen particles at an oxygen concentration, and wherein the oxygen particles include oxygen-comprising molecules;

heating the fraction of the surface layer at a heating temperature, wherein a combination of an oxygen concentration and the heating temperature is sufficient to oxidize the fraction of the surface layer; and

oxidizing the fraction of the surface layer with the oxygen-comprising molecules.

6. The method of claim 5, wherein the oxygen-comprising molecules are selected from the group consisting of molecular oxygen (O_2), nitrous oxide (N_2O), carbon dioxide (CO_2), and carbon monoxide (CO).

7. The method of claim 5, wherein the resistor includes an electrically resistive material selected from the group consisting of polysilicon, amorphous silicon, titanium, tantalum, tungsten, aluminum, silver, copper, nitrides thereof, silicides thereof, and alloys thereof.

8. The method of claim 5, wherein the chamber includes a heating source, wherein the heating step includes heating an interior of the heating chamber to the heating temperature by use of the heating source, wherein the heating of the interior of the heating chamber includes the heating of the fraction of the surface layer, and wherein $F = 1$.

9. The method of claim 5, wherein heating the fraction of the surface layer includes directing a beam into the fraction of the surface layer such that the beam causes the heating of the fraction of the surface layer, and wherein the beam is selected from the group consisting a beam of radiation and a beam of particles.

10. The method of claim 9, wherein the beam is the beam of radiation, and wherein the radiation includes a laser radiation.

11. The method of claim 10, wherein $F < 1$.

12. The method of claim 10, wherein $F = 1$.

13. The method of claim 1, wherein $F = 1$, and wherein the oxidizing step includes:

providing a plasma chamber that includes a first electrode and a second electrode;

disposing the semiconductor structure between the first electrode and the second electrode;

including a neutral gas within plasma chamber, wherein the neutral gas includes oxygen-comprising molecules;

ionizing the neutral gas to generate a plasma gas between the first electrode and the second electrode, wherein the plasma gas includes the oxygen particles as oxygen ions;

accelerating with a direct current voltage the oxygen ions from the first electrode toward the second electrode, wherein the accelerated oxygen ions strike the resistor with an energy that is at least a threshold energy for oxidizing the surface layer of the resistor; and

oxidizing the surface layer with the oxygen ions.

14. The method of claim 13, wherein the oxygen-comprising molecules are selected from the group consisting of molecular oxygen (O_2), nitrous oxide (N_2O), carbon dioxide (CO_2), and carbon monoxide (CO).

15. The method of claim 13, wherein the resistor includes an electrically resistive material selected from the group consisting of polysilicon, amorphous silicon, titanium, tantalum,

tungsten, aluminum, silver, copper, nitrides thereof, silicides thereof, and alloys thereof.

16. The method of claim 1, wherein the oxidizing step comprises:

forming an anodization electrical circuit which includes: a DC power supply, an electrolytic solution comprising oxygen, the resistor partially immersed in the electrolytic solution, and a cathode partially immersed in the electrolytic solution, wherein the resistor is electrically coupled to a positive terminal of the DC power supply such that the resistor serves as an anode, and wherein the cathode is electrically coupled to a negative terminal of the DC power supply;

activating the DC power supply such that the DC power supply generates a voltage output, wherein the voltage output causes an electrolytic reaction in the electrolytic solution near the resistor, wherein the electrolytic reaction generates oxygen ions from the oxygen in the electrolytic solution, and wherein the oxygen particles include the oxygen ions; and

oxidizing the fraction of the surface layer with the oxygen ions.

17. The method of claim 16, wherein $F < 1$.

18. The method of claim 16, wherein $F = 1$.

19. The method of claim 16, wherein the resistor includes an electrically resistive material selected from the group consisting of polysilicon, amorphous silicon, titanium, tantalum, tungsten, aluminum, silver, copper, nitrides thereof, silicides thereof, and alloys thereof.

20. The method of claim 1, wherein the oxidizing step includes:

providing a chemical solution which includes the oxygen particles, wherein the oxygen particles are selected from the group consisting of oxygen-comprising liquid molecules, oxygen ions, and an oxygen-comprising gas dissolved in the chemical solution under pressurization;

immersing the semiconductor structure in the chemical solution; and

oxidizing the fraction of the surface layer of the resistor by chemically reacting the oxygen particles with the fraction of the surface layer.

21. The method of claim 20, wherein the resistor includes an electrically resistive material selected from the group consisting of copper, tungsten, aluminum, titanium, nitrides thereof, and alloys thereof.

22. The method of claim 20, wherein the chemical solution is selected from the group consisting of hydrogen peroxide, ferric nitrate, and ammonium persulphate.

23. The method of claim 1, further comprising:

providing a predetermined target resistance in terms of a value R_t and a tolerance ΔR_t for the electrical resistance of the resistor; and

testing the resistor during the oxidizing step to determine whether the electrical resistance of the resistor is within $R_t \pm \Delta R_t$.

24. The method of claim 23, wherein during the testing step the electrical resistance of the resistor is determined to not be within $R_t \pm \Delta R_t$, and further comprising iterating such that each

iteration of the iterating includes additionally testing the resistor during the oxidizing step to determine whether R_2'' is within $R_t \pm \Delta R_t$, and ending the iterating if R_2'' is within $R_t \pm \Delta R_t$ or if $(R_2''-R_1)(R_t-R_2'') < 0$, wherein R_1 is an electrical resistance of the resistor prior to the oxidizing of the portion of the resistor, and wherein R_2'' is a latest value of the electrical resistance of the resistor as determined by the testing.

25. An electrical structure, comprising:

a semiconductor structure that includes a resistor; and

oxygen particles in an oxidizing reaction with a fraction F of a surface layer of the resistor, wherein the oxidizing reaction increases an electrical resistance of the resistor.

26. The electrical structure of claim 25, wherein $F = 1$.

27. The electrical structure of claim 25, wherein $F < 1$.

28. The electrical structure of claim 25, wherein a dimension of the fraction of the resistor does not exceed about 1 micron.

29. The electrical structure of claim 25, further comprising:

a chamber in which the semiconductor structure has been placed;

a gas within the chamber, wherein the gas includes the oxygen particles at an oxygen concentration, and wherein the oxygen particles include oxygen-comprising molecules;

the fraction of the surface layer being heated at a heating temperature, wherein a combination of an oxygen concentration and the heating temperature is sufficient to oxidize the fraction of the surface layer; and

the fraction of the surface layer being oxidized by the oxygen-comprising molecules.

30. The electrical structure of claim 29, wherein the oxygen-comprising molecules are selected from the group consisting of molecular oxygen (O_2), nitrous oxide (N_2O), carbon dioxide (CO_2),

and carbon monoxide (CO).

31. The electrical structure of claim 29, wherein the resistor includes an electrically resistive material selected from the group consisting of polysilicon, amorphous silicon, titanium, tantalum, tungsten, aluminum, silver, copper, nitrides thereof, silicides thereof, and alloys thereof.

32. The electrical structure of claim 29, wherein the chamber includes a heating source, wherein an interior of the heating chamber is being heated at the heating temperature by use of the heating source, wherein the heating of the interior of the heating chamber includes the surface layer being heated at the heating temperature, and wherein $F = 1$.

33. The electrical structure of claim 29, wherein the fraction of the surface layer is being heated by a directed beam which imparts energy into the fraction of the surface layer, and wherein the beam is selected from the group consisting a beam of radiation and a beam of particles.

34. The electrical structure of claim 33, wherein the beam is the beam of radiation, and wherein the radiation includes a laser radiation.

35. The electrical structure of claim 34, wherein $F < 1$.

36. The electrical structure of claim 34, wherein $F = 1$.

37. The electrical structure of claim 25, wherein F = 1, and further comprising:

a plasma chamber that includes a first electrode and a second electrode;

the semiconductor structure disposed between the first electrode and the second electrode;

a plasma gas between the first electrode and the second electrode, wherein the plasma gas includes the oxygen particles as oxygen ions, and wherein the oxygen ions have been formed from an ionization of oxygen-comprising molecules in a neutral gas within the plasma chamber;

the oxygen ions being accelerated from the first electrode toward the second electrode and into the resistor with an energy that is at least a threshold energy for oxidizing the surface layer of the resistor, wherein the oxygen ions are being accelerated by a direct current voltage; and

the surface layer being oxidized by the oxygen ions.

38. The electrical structure of claim 37, wherein the oxygen-comprising molecules are selected from the group consisting of molecular oxygen (O_2), nitrous oxide (N_2O), carbon dioxide (CO_2), and carbon monoxide (CO).

39. The electrical structure of claim 37, wherein the resistor includes an electrically resistive material selected from the group consisting of polysilicon, amorphous silicon, titanium, tantalum, tungsten, aluminum, silver, copper, nitrides thereof, silicides thereof, and alloys thereof.

40. The electrical structure of claim 25, further comprising:

an anodization electrical circuit, including: a DC power supply, an electrolytic solution,

the resistor partially immersed in the electrolytic solution, and a cathode partially immersed in the electrolytic solution, wherein the resistor is electrically coupled to a positive terminal of the DC power supply such that the resistor serves as an anode, and wherein the cathode is electrically coupled to a negative terminal of the DC power supply;

a voltage output from the DC power supply, wherein the voltage output causes an electrolytic reaction in the electrolytic solution near the resistor, wherein the electrolytic reaction generates oxygen ions, and wherein the oxygen particles include the oxygen ions; and

the fraction of the surface layer being oxidized by the oxygen ions.

41. The electrical structure of claim 40, wherein $F < 1$.

42. The electrical structure of claim 40, wherein $F = 1$.

43. The electrical structure of claim 40, wherein the resistor includes an electrically resistive material selected from the group consisting of polysilicon, amorphous silicon, titanium, tantalum, tungsten, aluminum, silver, copper, nitrides thereof, silicides thereof, and alloys thereof.

44. The electrical structure of claim 25, further comprising:

a chemical solution including the oxygen particles, wherein the oxygen particles are selected from the group consisting of oxygen-comprising liquid molecules, oxygen ions, and an oxygen-comprising gas dissolved in the chemical solution under pressurization.

the semiconductor structure immersed in the chemical solution; and

the fraction of the surface layer of the resistor being oxidized by a chemical reaction between the oxygen particles and the fraction of the surface layer.

45. The electrical structure of claim 44 wherein the resistor includes an electrically resistive material selected from the group consisting of copper, tungsten, aluminum, titanium, nitrides thereof, and alloys thereof.

46. The electrical structure of claim 44, wherein the chemical solution is selected from the group consisting of hydrogen peroxide, ferric nitrate, and ammonium persulphate.

47. A method for increasing an electrical resistance of a resistor, comprising the steps of:

providing a semiconductor structure that includes the resistor; and

nitridizing a fraction F of a surface layer of the resistor with nitrogen particles, resulting in the increasing of the electrical resistance of the resistor.

48. An electrical structure, comprising:

a semiconductor structure that includes a resistor; and

nitrogen particles in an nitridizing reaction with a fraction F of a surface layer of the resistor, wherein the nitridizing reaction increases an electrical resistance of the resistor.